Стреляная Ю.О. Обеспечение стабильности параметров качества изделий за счет устранения эксцентриситета обрабатываемой заготовки на тяжелых станках // Транспортное, горное и строительное машиностроение: наука и производство. – 2019. – №2. – С. 36-41.

УДК 621.941.01 https://doi.org/10.26160/2658-3305-2019-2-36-41

ОБЕСПЕЧЕНИЕ СТАБИЛЬНОСТИ ПАРАМЕТРОВ КАЧЕСТВА ИЗДЕЛИЙ ЗА СЧЕТ УСТРАНЕНИЯ ЭКСЦЕНТРИСИТЕТА ОБРАБАТЫВАЕМОЙ ЗАГОТОВКИ НА ТЯЖЕЛЫХ СТАНКАХ

Стреляная Ю.О.
Севастопольский государственный университет, г.Севастополь

Ключевые слова: эксцентриситет, точность, токарный станок, чистовое точение, заготовка.
Аннотация. Разработана методика ускоренного исправления эксцентриситета на при точении заготовок на тяжелых станках. Использование данного способа позволяет сократить количество проходов, необходимых для исправления эксцентриситета и обеспечить стабильность параметров качества обработанных поверхностей.

THE STABILITY OF PARAMETERS OF PRODUCTS QUALITY BY ELIMINATING ECCENTRICITY BY TURNING OF WORKPIECES OF HEAVY MACHINES

Strelyanaya Yu.O.
Sevastopol state university, Sevastopol

Keywords: eccentricity, precision, lathe, finishing turning, workpiece.
Abstract. The technique of accelerated correction of eccentricity on turning blanks on heavy machines. The use of this method allows to reduce the number of passes necessary to correct the eccentricity and ensure the stability of the quality parameters of the treated surfaces.

Production of heavy metallurgical, power, transport equipment is the basis of mechanical engineering of the Russian Federation and an important part of its exports. The possibility of manufacturing heavy machines, competitive in the world market, is provided by the equipment of machine-building enterprises with modern machine tools. The main group of machine Park of machine-building enterprises of the country is lathes. Most parts of heavy duty turbines and generators, marine vessels, rolling mills and other machines are machined with numerical control on heavy duty lathes with virtually no limit on size, weight and accuracy [1].

The application of new methods of producing blanks, reduced machining allowances, and improving the design tool, the creation of numerical control (NSC) machines of high and especially high precision, high quality pre-treatment allowed as finishing operations use processes to finish turning.

However, despite the positive effects of new methods of obtaining blanks, still not eliminated the shortcomings associated with the technological heredity of the process (the presence of a significant residual eccentricity of the workpiece after roughing and related tasks of installation and reconciliation of parts to perform finishing operations).

Currently, finishing turning on heavy equipment is carried out using traditional methods that do not fully take into account the influence of random factors that reduce the stability of the quality of processed products. Large masses and dimensions of parts, their uniqueness (fig.1), the high cost, labor intensity of machining require special conditions, which are significantly different from traditional solutions for light and medium-sized machines [2]. When processing products on heavy machines, taking into account the unsteadiness of the process associated with a change in the state of the technological system, in the development of technological processes and methods of control of lathes will increase the productivity of the process, reduce the cost of processing parts, improve the accuracy of final turning [3].

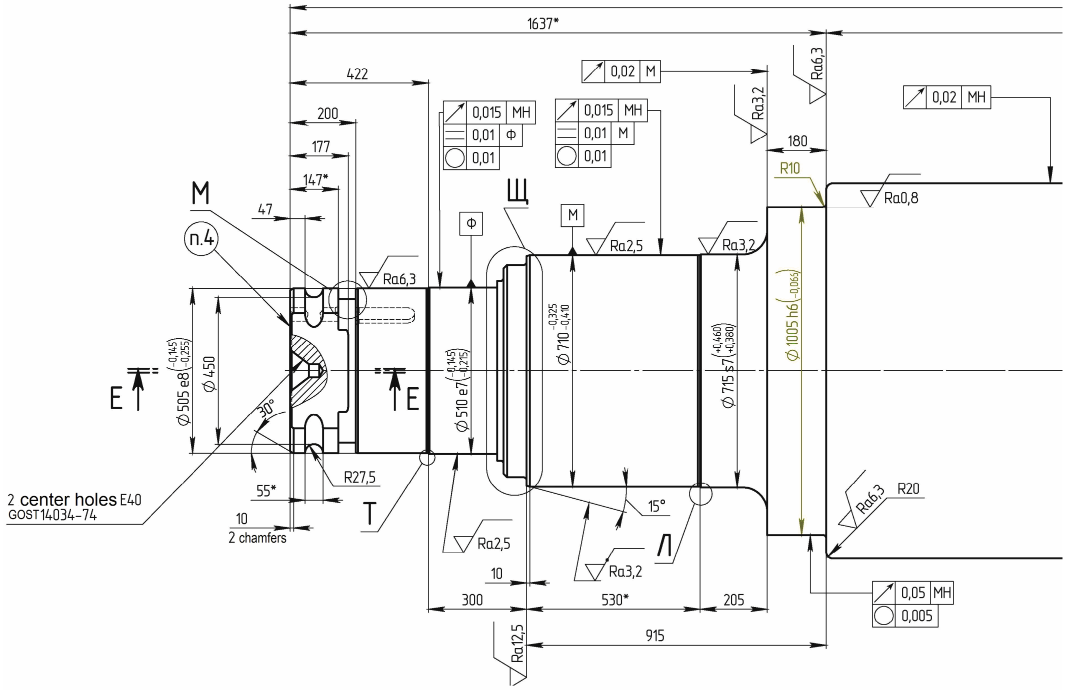

Fig. 1. A portion of a drawing roll mill

At the stage of final turning, with the re-installation of the part there is a significant eccentricity, which has a negative impact on the output quality of the treated surface.

The aim of the work is to develop a way to eliminate the eccentricity and ensure the accuracy of the position of the workpiece after roughing. Experimental studies were carried out on samples with a diameter of 1500 mm after roughing and semi-finishing.

The essence of the method is as follows: to correct the original eccentricity of the workpiece ε_1, an additional eccentricity is created $\Delta\varepsilon$ between the center of the part and the axis of its rotation. Processing is carried out with the displacement of the axis of the outer surface of the part relative to the axis of rotation $\varepsilon_2 = \varepsilon_1 - \Delta\varepsilon$. The value of the additional eccentricity specified $\Delta\varepsilon$ is determined from the expression:

$$\Delta\varepsilon = \frac{\varepsilon_1 (1 - E)^{m_z}}{1 - (1 - E)^{m_z}}, \qquad (1)$$

where ε_1 – initial eccentricity of the workpiece, mm; E – coefficient that depends on the circumstances turning; m_z – number of passes;

The value of the initial eccentricity ε_1, determined by measuringValue of coefficient E determined from the following ratio:

$$E = \frac{j}{K + j}, \qquad (2)$$

where j – rigidity of the technological system, N/m; K – coefficient that depends on the circumstances turning, N/m.

Value of coefficient K, constant for these processing conditions, defined as follows:

$$K = \frac{P_y}{t \cdot \chi}, \qquad (3)$$

where P_y – radial cutting force, N; t – depth of cut, m;

Coefficient m_z for turning with longitudinal feed characterizes the number of passes necessary to correct the original eccentricity ε_1. Its value is calculated according to the dependence:

$$m_z = \frac{P + \varepsilon_1 - \Delta\varepsilon}{t}, \qquad (4)$$

where P – the minimum seam allowance on the side, m.

Time spent on the turning process to correct the original eccentricity:

$$\tau = \frac{L \cdot m_z}{nS}, \qquad (5)$$

where n – spindle rotation frequency, rot/s; L – length of surface to be treated, m; S – longitudinal feed, m/rot

The use of this method of eccentricity correction can be effectively used in the adaptive system of a heavy lathe.

On the basis of the proposed method, a method for ensuring the accuracy of the workpiece is developed.

To implement the above method, experimental studies were conducted. Experiments were carried out on the machine for finishing turning CTU3500M(H) TORNI TACCHI, with the system NSC Sinumeric 840D, equipped with tensometric devices that allow to measure the amount of cutting forces during processing and determine the rigidity of the technological system. The number of revolutions of the machine spindle was selected from the condition of ensuring the cutting speed 125 m/min.

As experimental samples, samples with a diameter of 1500 mm with initial eccentricity were made (table 1). When turning using a special movable support and the center allow you to specify a certain value of the additional eccentricity $\Delta\varepsilon$.

Cutting tool: lathe cutter with a plate of mixed ceramics based on aluminum oxide (CC650). Cutting conditions were assigned according to existing recommendations and calculation data.

Allowance is removed when turning equal to 0,3 mm. Measurement of eccentricity before and after treatment ε_1 , and ε_{res} (fig. 2) laser interferometer was used to measure the radial runout of the outer diameter.

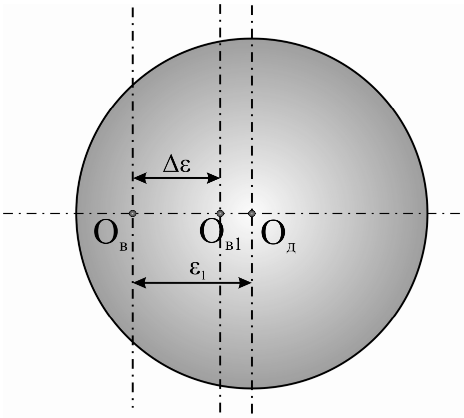

Fig. 2. Scheme for the implementation of the method of correction of eccentricity

The value of the initial eccentricity ε_1 was defined as the radial beating of the outer diameter.

Before the beginning of the experiments, the rigidity of the technological system was determined.

The depth of cut in one pass was calculated according to:

$$t = \frac{(d_0 - d)}{2 \cdot m_z}, \quad (6)$$

where d_0 – the diameter of the workpiece before processing, mm; d – the diameter of the workpiece after processing, mm.

The average value of the allowance taken for 6 passes of the cutter was 0.3 mm at these cutting conditions. Average depth of cut determined by the formula (6), $t = 0{,}05$ mm. The average value of the effort $P_y = 54{,}6H$

The value of the coefficient K determined:

$$K = \frac{P_{y\,cp}}{t \cdot \chi} = \frac{54{,}6}{0{,}05 \cdot 10^{-6}}, \; K = 10{,}92 \cdot 10^{8}.$$

Coefficient E on expression (2):

$$E = \frac{j}{K + j} = \frac{1{,}79 \cdot 10^{8}}{10{,}92 \cdot 10^{8} + 1{,}79 \cdot 10^{8}} = 0{,}14.$$

The required number of passes from expression (4) is:

$$m_z = \frac{0,3+0,06}{0,05} = 7,2 .$$

Values of constants and coefficients required for calculation of additional eccentricity $\Delta\varepsilon$, summarized in the table 1.

Tab. 1. The values of the coefficients to calculate $\Delta\varepsilon$

j , N/m	K , N/m	E	m_z	$\Delta\varepsilon = \frac{\varepsilon_1(1-E)^{m_2}}{1-(1-E)^{m_2}}$
$1,79 \cdot 10^8$	$10,92 \cdot 10^8$	0,14	7	$E = \frac{j}{K+j}$

At the given cutting conditions, the workpieces were processed without displacement of the rotation axis ($\Delta\varepsilon$ = 0) and with the added eccentricity ($\Delta\varepsilon \neq 0$), the value of which for each particular case on the basis of the data given in table 2, and the value of the initial eccentricity of the workpiece was calculated by the formula (1). The total eccentricity was determined from the ratio $\varepsilon_2 = \varepsilon_1 - \Delta\varepsilon$.

The results of the experiments are summarized in table 2.

Tab. 2. The results of the experiments (finishing turning)

№ experi-ment	Initial eccentricity of the workpiece ε_1 , mm	Additional offset $\Delta\varepsilon$, mm	The residual eccentricity ε_{res} , mm	Number of passes without additional offset, m_z	Number of passes with additional offset, m
1	0,055	0	0,016	7	
2	0,060	0	0,019	7	
3	0,062	0	0,018	7	
4	0,070	0	0,022	8	
5	0,055	0,029	0,007		6
6	0,060	0,032	0,007		6
7	0,062	0,033	0,009		6
8	0,070	0,037	0,008		7

On the basis of the conducted researches it is established: for correction of initial eccentricity of preparations $\varepsilon_1 = 0,055 \div 0,07$ mm, $\varepsilon_{res} = 0,004 \div 0,008$ mm, when turning without specifying an additional offset, it is necessary to make up to 7 passes, i.e. 1.5 times more than when turning with $\Delta\varepsilon \neq 0$.

Presence of residual eccentricity ε_{res} after turning with optional offset $\Delta\varepsilon \neq 0$ it is explained by the presence of errors in the experiments, as well as the fact that the turning, as well as any process, inherent in the creation of errors inherent in the process.

The experiments have shown the possibility of using this method to correct the original eccentricity of the workpieces. The use of this method allows to reduce the number of passes required to correct the eccentricity, improve the accuracy and performance of the turning process.

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Сведения об авторах:	*Information about authors:*
Стреляная Юлия Олеговна – к.т.н., доцент, кафедра «Технология машиностроения», Севастопольский государственный университет, г.Севастополь, joulia.bayrakova@mail.ru	**Strelyanaya Yuliya Olegovna** – candidate of technical sciences, associate professor, Department of Mechanical Engineering, Sevastopol state university, Sevastopol, joulia.bayrakova@mail.ru

Получена 30.03.2019